Multiple Measures of Numerical Cognition and Quantifier Interpretation

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by

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Abstract

How do numerical knowledge and knowledge of language interact? There has been a great deal of work that tries to explain how language is used in counting and mathematics, but less work has been done trying to explain how numerical ability might relate to language ability. A reasonable place to begin to look are the natural language quantifiers (e.g. *some, all, none, each, few,* etc.). An example of a plausible math-language connection is found in sentences with quantifiers that represent collective or distributive actions. Children across an array of languages are delayed in learning to interpret such distributive and collective sentences. For example, *Each minion pushed a rock.* is accepted by children in collective contexts, in which there is one rock pushed by multiple minions together, which adults reject. While much of language is acquired early, this interpretative ability is delayed until children are roughly 11 years old. An as-yet unexplored connection would be between the domain of language that is responsible for these interpretations and children's numerical knowledge. In this project, we use four different tests of child numerical knowledge and independently test children's distributive-collective linguistic interpretations to determine to what degree, if any, these aspects of number and these aspects of language are related. Our four numerical tests include pre-linguistic analog magnitude estimation, symbolic and non-symbolic number line estimation and number set calculation. Our linguistic measure of quantifier interpretations is receptive experiment in which children watch a video depicting collective or distributive actions and are then asked whether a sentence describing the video in either collective or distributive terms is correct. Results showed that children in our dialect categories were not significantly different from one another in their numerical abilities, but that they were different in their quantifier interpretations. Quantifier interpretations and numerical abilities did not correlate. This shows that dialect variation in

African American vernacular and mainstream English acts as a language obstacle that is only seen in quantifier interpretations. Consequences of our findings are relevant to the relationship among cognitive abilities deployed in mathematical reasoning and other linguistic expressions of number.

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Introduction

Quantifiers seem to be this vague aspect of our understanding of language that are on the border of language and number. Inherently, quantifier words are simply that- words, but with an added semantic numerical meaning attached. The quantifier *each* is the most obscure, and apparently challenging for children to acquire, of them all, as shown in a study done by Hanlon in 1986. Ever since then, scientists have been working to better understand just what it is that makes the distributive and collective interpretations of the plural quantifiers so difficult to grasp. While most understandings of language are solidified by the age of four, it takes until 10 or 11 years old for children to have a grasp of this, and even then, not reaching adult like levels of performance (Brooks & Braine 1996). This phenomenon occurs cross-linguistically, with studies not only in English, but also in Mandarin, Portuguese, and Italian (Brooks, Braine, Jia & Da Graça Dias 1998).

Due to the implicit associations between the number sense and natural language quantifiers, it could be valuable to look at children's understanding of implicit number systems and correlate them to their performance on a Truth Value Judgement Task – a task that is given to measure children's understanding of quantifiers. In what follows, we report the result of a series of number measures as well, including the Panamath test, which measures the Approximate Number System by using inexact number representations (Halberda, Mazzocco & Feigenson 2008). Similarly, the Number Line Task uses Arabic numerals and collections of dots to evaluate how adult-like children are in their Approximate Number System and exact numerical quantifier representations, respectively.

Lastly, language variation plays a key role in lexical development. Among other things, bilingual children are known to have smaller single-language lexicons (e.g. Bialystok & Craik

2010). However, little is known about how being bi-dialectal affects lexical development. Though we will not measure the lexicon directly, we will assume that this is primarily what distinguishes the children in our Mainstream and Variation-from-Mainstream samples. The relevance of lexical development is that it has been shown to be predictive in child English (Oates 2017) and in child Spanish of collective-distributive interpretations (Padilla-Reyes, Nieves-Rivera & Grinstead 2015). Thus, determining whether use of distinct English language dialect varieties influences children's quantifier interpretations will be one area explored here.

The Development of Collective and Distributive Interpretations

We now turn to a review of the evidence for a pattern of delayed acquisition of, especially, distributive interpretations in children. There is less work on collective interpretations. Our first study comes from the work of Camille Hanlon.

Hanlon (1986)

In 1986, Hanlon carries out a pair of act-out task experiments with children aged 3 to 7;11 in which children are given a command that varies as a function of the quantifier it contains. One of the tasks in this set is the Letters task, where children are told "Put (quantifier) of the letters in a box." In the related "Cookies" task, children are instructed to "Give him (quantifier) of the cookies." to the Cookie Monster. Possible quantifiers are {*all, none, some, any, other, another, each, both, either, neither*}. The Letters Task included a container with 6 compartments, into which 4 letters could be placed. The distributive response, with *each*, was considered to be each of the 4 letters put into an individual compartment. For the Cookies task, the dimension of distributivity at issue was temporal and not spatial, as in the Letters task, and the distributive response was expected to consist of each cookie being offered to Cookie Monster in an individual act of giving. Results showed that of the possible quantifiers {*all, none, some, any, other, another, each, both, either, neither*}, the distributive quantifier *each* was the most challenging for children, with 31% correct in the Letters task and 3% correct in the Cookies task. In contrast, with *all*, children performed at 100% in both tasks.

This experiment showed that 4 through 7-year-olds' comprehension on the use of the quantifier *each* is limited at best. While the participants passed most of the other quantifier comprehension tests with scores ranging from 80% - 100%, the majority of the time, the comprehension of the quantifier *each* is significantly stunted. This finding indicated, 35 years ago, that children have a difficult time understanding the quantifier *each*.

Brooks and Braine (1996)

Brooks and Braine really hone-in on the importance of the quantifier *each* in their experiments, building on Hanlon's work in 1986. They carry out three experiments, all with English-speaking children ages 4-10. The first experiment shows the child two pictures, a subject-exhaustive picture, and an object-exhaustive picture. These pictures are of, for example, men carrying boxes. The experimenter reads off the corresponding sentence for one of the pictures, and the child is asked to pick the picture that best matches the sentence read. The distributive quantifier *each* was the hardest for children to understand, as the averages, starting from age 4 and going to age ten are shown below.

Age in Years	Percent Correct *each*	Percent Correct *all*
4	46.7	83.3
5	46.7	96.7
6	66.7	100
7	90.0	100
8	63.3	100
9	83.8	100
10	90.0	100

Table 1 – Comparison of Percent Correct for Distributive *each* and Non-distributive *all* (adapted from Brooks & Braine 1996, p. 244, Table 1)

Here we see a replication of the special difficulty associated with the distributive *each* quantifier, which only differs from *all* in being distributive, as they are both universal quantifiers.

The second experiment was also carried out with children of the same age. In this experiment, the children were asked to match the sentence with the picture, however, the position of the quantifier was switched. The first sentence reads "Each actor is building a boat." and the second reads "A boat is being built by each actor". This switch is to see if there might be a sentence form - active vs. passive - that is easier for comprehension of the quantifier. Results indicate the distributive quantifier *each* in passive sentences was the hardest for the children to comprehend. In this analysis, a low score is ideal.

Age in Years	Response Each – active	Response Each- passive
4	37.8	62.2
5	44.2	71.7
6	26.7	52.5
7	24.4	46.7
8	1.1	37.8
9	6.7	23.3
adult	0.8	17.5

Table 2- Comparison of Active and Passive Voice of "Each" (adapted from Brooks & Braine 1996, p. 250, Table 3)

In conclusion, children ages 4-6 generally accept both collective and distributive interpretations of sentences, while 7-9-year-olds generally accepted the distributive version as seen in table 1. However, for a passive interpretation of *each*, only 9-year-olds understood it, and even then, not at the level of an adult.

In the third experiment, collected from children aged 5-9;11, collective and distributive versions of *each* were taken into account. "each actor is (verb)ing an object" and the verbs (*wash, carry, feed)* were used. Three pictures were presented to the children and they were asked to pick one picture that best went with the sentence being read aloud. Once again, children had trouble accepting *each* as the distributive quantifier it is. A high score is the goal for this experiment (100%), and the results are shown below.

Age in Years	Response Each- distributive
5	41.7
6	72.2
7	80.6
8	80.6
9	77.8
adult	97.2

Table 3- Percentages of responses in which subjects selected distributive interpretations of the quantifier “each”. (adapted from Brooks & Braine 1996, p. 258, Table 5)

In conclusion, the distributive property of *each* is accepted after the age of 6, however adult like levels of comprehension is not even fully reached at 9. This study focused on the age range of the participants and narrowed down the age ranges at which a child begins to grasp the concept of distributive and collective uses of *each*.

<u>Brooks, Braine, Jia & Da Graça Dias (1998)</u>

Two years later, Brooks and colleagues begin another study. This time, the picture choice task from Brooks and Braine (1996) was adapted to Mandarin, Portuguese, and English, to understand universal quantifiers, including *each*. Experiment 1 explores whether Chinese children show similar preferences to adults with sentences using the distributive interpretation. Mei3 (the “3” represents a lexical tone in Mandarin) is the distributive “each” equivalent in Chinese. Forty 3- and 4-year-olds, forty 5- and 6-year-olds, forty 7- and 8-year-olds, forty 9- and

10-year-olds, and forty adults participated in this study. The participants were presented with two sets of pictures with collective, distributive, and exhaustive states. Three pictures were presented at a time, and participants had to select the picture that best matches with the statement read aloud. The pictures are shown below.

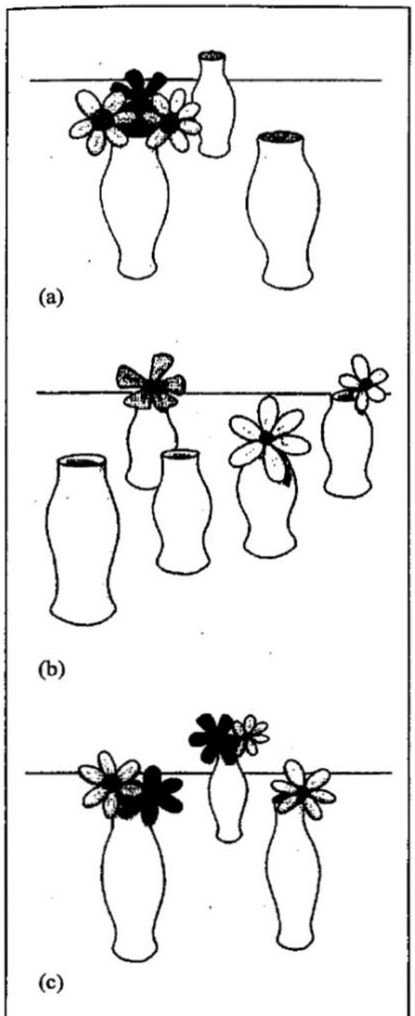

Fig. 1 Picture choices for the locative context: (a) non-exhaustive collective, (b) non-exhaustive distributive, (c) exhaustive

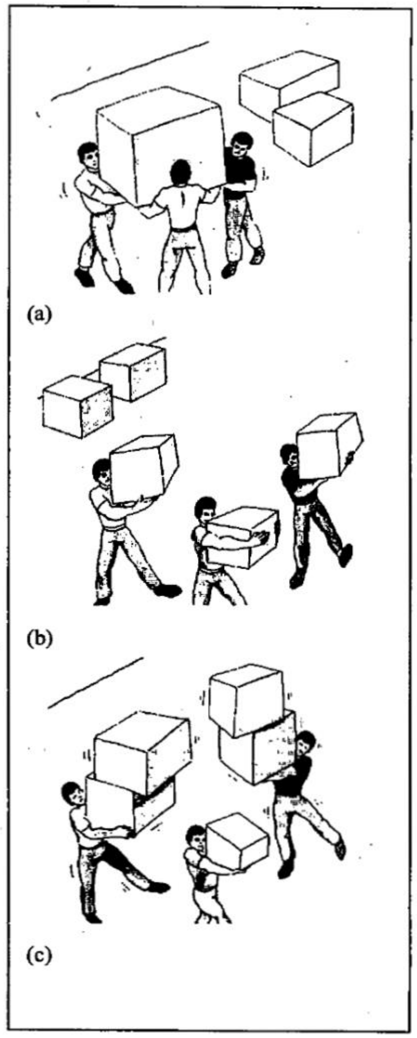

Fig. 2 Picture choices for the actional context: (a) non-exhaustive collective, (b) non-exhaustive distributive, (c) exhaustive

Figure 1- the stimuli administered in the “Picture Choice” task. Adapted from Brooks & Braine 1998, p. 45, Figure 1

The distributive "mei3" showed a preference for the distributive interpretation around age 5. "Each man is carrying a box" showed a massive leap in comprehension between ages 3/4 and ages 5/6, from 0.4 to 0.85. However, "each flower is in a vase" shows an increase in comprehension from ages 7/8 to ages 9/10, with scores going from 0.65 to 0.85. An influencing factor is that the word "Doul" is believed to add a collective cue to the sentence, which conflicts with the distributive interpretation of "mei3", which may have influenced the confusion between distributive and collective meanings of the word, explaining the age differences in comprehension.

In experiment 2, "cada" is the Portuguese equivalent of the English quantifier "each". The distributive interpretation of "each" is again being studied in this experiment. The participants are twenty-four 4-year-olds, twenty-four 5-year-olds, twenty-four 6-year-olds, twenty-four 7-year-olds, twenty-four 8-year-olds, twenty-four 9-year-olds, and 40 adults. Once again, the picture triads were used. The results showed that the scores for the age groups increased incrementally over age groups, yet a firm understanding of the distributive use of "cada" is never fully developed. The scores are 1.3,1.1, 1.8, 2.1, 2.4, 2.6, and 2.9. This ranges from ages 4 to 10 and adult.

In experiment 3, the study was done in English with 57 4-year-olds, 57 5-year-olds, 57 6-year-olds, 57 7-year-olds, 57 8-year-olds, 57 9/10-year-olds, and 57 adults. The same picture triads as the first two experiments were used. Once again, the distributive meaning for the quantifier "each" is not fully grasped, even at the age of 9.

Age	Each flower is in a vase	Each man is carrying a box
4	0.5	1.4
5	0.7	1.3
6	1.1	2.2
7	1.5	2.4
8	1.9	2.4
9	1.8	2.3
adult	2.7	2.9

Table 4- Comparison of scores between object states and actional context (adapted from Brooks & Braine 1998, p. 66-67, Table 3)

In sum, Brooks et al. (1998) is consistent with the existing literature in that the distributive meaning of *each* is slow to develop, relative to other quantifiers, and this is true in Mandarin and Brazilian Portuguese, as it is in English. Brooks et al. (1998) demonstrated that universally, comprehension of the distributive and collective forms of the quantifier *each* is stunted unlike any other forms of language.

At this point it is known that the quantifier *each* takes the longest to develop, often developing between the ages of 6-8, yet never fully reaching adult-like levels of comprehension. The distributive and collective properties of *each* are both found to be difficult to fully grasp. This phenomenon is also replicated in languages as well. Moving forward, scientists look to identify the factors that are underlying this difficulty in comprehension of the quantifier.

Musolino (2009)

In 2009, Musolino decided to study the logico-syntactic properties of NQEs (nominal quantified expressions), such as “three boys” in sentences such as *Three boys are holding each balloon.* to understand numerical implications. In his experiment, 32 children (4;4 to 6;2) and 32 adults (undergraduates at Indiana University) are tested to see if they have knowledge of the logico-syntactic properties associated with the use of the NQE. The participants are given a Truth Value Judgement Task, which involves viewing pictures of boys holding balloons, and determining whether the spoken statement that follows the picture is correct or not. In certain sentences, quantifier type is manipulated to differ from object or subject.

The results show that in the cumulative context (where multiple children are holding a single balloon), children have a difficult time comprehending the use of “each”. The baseline score from the adults of 17.1%, while the children scored 54.6%, which illustrates that children are less restrictive with the use of the distributive quantifier *each* than are adults. In other words, children tend to accept a statement when they are unsure- following the “yes bias”.

When given the chance to choose between distributive or collective interpretations, children tend to assign a distributive meaning to *each*, even more than do adults. Thus, with a sentence like *Three boys are holding each balloon.*, when paired with a drawing such as the following, children have a higher acceptance of the pairing (90.6%) than do adults (31.2%).

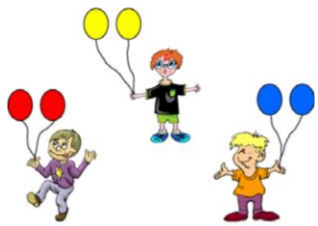

Figure 2 – Adapted from Table 1, p. 33, Musolino (2009)

A theory as to why there are these prevalent differences in children and adults is simply exposure. Preschools may know the meaning of each word separately, but simply do not have the developed semantic skills to understand the grammar implicatures.

Pagliarini (2012)

A Truth Value Judgement Task (TVJT), similar to the one given by Musolino in 2009, is used again by Pagliarini, this time in Italian and this time focusing just on distributive and collective interpretations. The task is given on a computer screen and the participants are asked to select a correct sentence (read aloud during the presentation of the stimulus) that matches with a scenario, depicted by a static picture, shown on the computer screen. This experiment was run on 12 four-year old's, 20 five-year old's, 16 six-year old's, 20 seven-year old's, 22 eight-year old's, 21 nine-year old's, 20 ten-year old's, 15 eleven-year old's, 17 twelve-year old's, 26 thirteen-year old's, and 97 adults. Regarding the distributive quantifier *ciascun* (*each*) in the scenario "each boy built a sandcastle" in collective contexts (Condition B), young children accepted the collective interpretation at high levels. The uniquely distributive interpretation of the quantifier is not fully grasped until the age of 11. In a parallel, in fact, correlated fashion, Condition C, which included the collective definite plural subject (with Italian *i* or *le*) in distributive contexts, also seemed to be acquired quite late.

Most importantly, children's acceptance of the collective interpretations of *i* and *le* in distributive contexts could be predicted by their acceptance of the distributive *ciascun* in collective contexts. Pagliarini et al. (2012) were the first to show that collective and distributive quantifiers appear to develop in a correlated fashion, consistent with the claim by one of Pagliarini's colleagues, Jakub Dotlačil, that there is a Collective-Distributive Pragmatic Scale. On this hypothesis, the lexical, pragmatic scale is anchored by *each* at the distributive extreme, and from there, the rest of the plural quantifiers in the language, which are inherently ambiguous between collective and distributive, come to mean almost exclusively collective, by virtue of *each* being more informative, following the logic of Gricean pragmatics (Grice 1975; Horn 1972, 1989).

	Proportion of 'true' answers			
Group	Cond. A	Cond. B	Cond. C	Cond. D
4YO	96 (8)	89 (25)	96 (10)	93 (11)
5YO	100 (0)	92 (23)	99 (4)	97 (7)
6YO	98 (6)	81 (34)	98 (6)	99 (4)
7YO	100 (0)	67 (45)	99 (4)	100 (0)
8YO	100 (0)	49 (46)	95 (18)	100 (0)
9YO	100 (0)	39 (42)	92 (15)	96 (10)
10YO	100 (0)	26 (33)	88 (24)	98 (5)
11YO	100 (0)	10 (27)	76 (24)	98 (6)
12YO	98 (6)	11 (22)	71 (29)	100 (0)
13YO	99 (3)	11 (19)	72 (30)	98 (5)
AD	96 (10)	9 (18)	50 (32)	98 (13)

Table 5- Answer response from the TVJT across age ranges and sentence structures. (Adapted from Pagliarini 2012, P. 8, Table 2).

In conclusion, there is a statistically significant regression within these conditions, indicating that age is a significant indicator of collective- distributive quantifier meaning. This concept is studied more by Padilla-Reyes in 2018 and Grinstead, Padilla-Reyes & Nieves-Rivera (2021).

Grinstead, Padilla-Reyes & Nieves-Rivera (2021)

In this experiment, the developmental connection between plural determiners and collective-distributive interpretations were explored. 88 monolingual Spanish speakers with no speech, hearing or language impairments between the ages of 5 and 10 were given the Truth Value Judgement Task. They were shown a stop-motion video with voice over narration, and shown 36 experimental scenarios, 12 filler scenarios, and 4 warm up scenarios. 12 of the experimental sentences use the distributive quantifier *cada* (each): half in congruent, distributive, contexts and half in incongruent, collective contexts. Similarly, collective quantifiers *unos* (some) and *los* (the) were presented in congruent, collective contexts and in incongruent, distributive contexts. All stimuli were presented in contexts created by a voice-over narration that played while action was portrayed using stop-motion animation of the "minion" characters from the movie *Despicable Me*.

Results showed the youngest segment of the sample (5-year-olds) accepting both distributive and collective interpretations of both types of quantifier sentences. By 6, they begin to refine the meaning and discriminate more, rejecting the incongruent contexts. Consistent with previous research, children are 10 years-old before they approach adult-like levels of rejection, as illustrated in Figure 3.

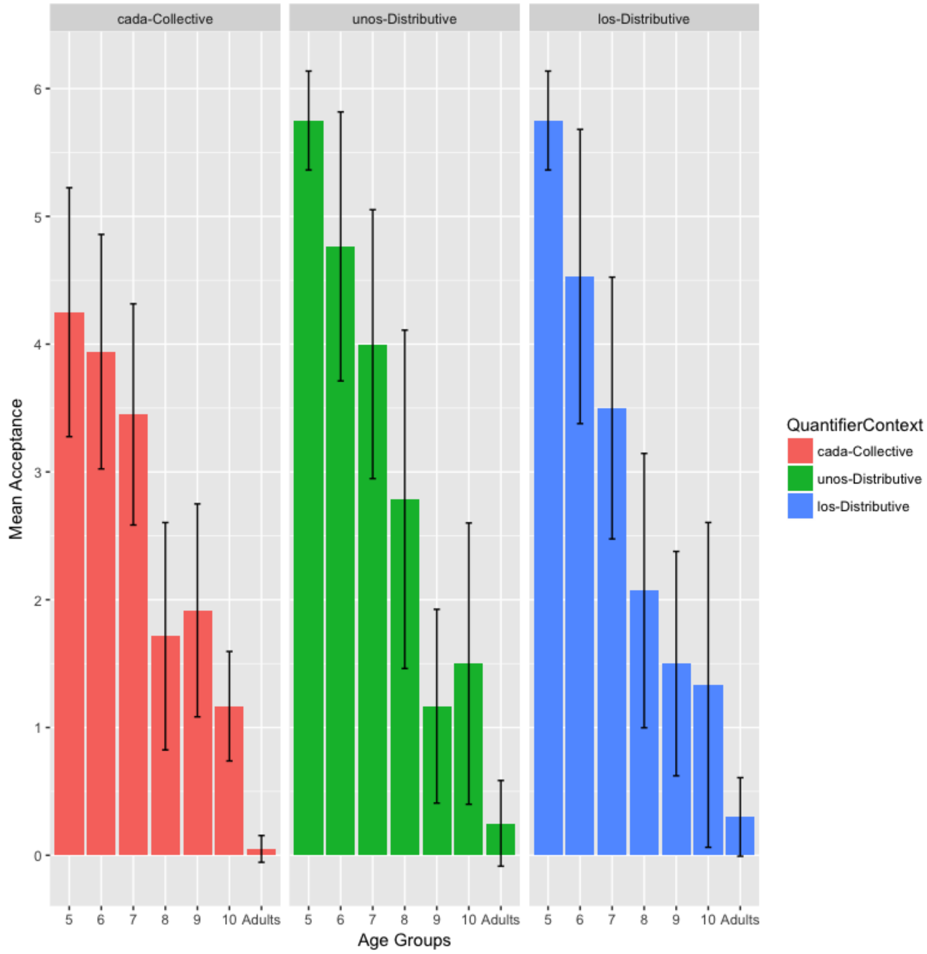

Figure 3 – Cross-sectional Distributive-Collective Quantifier Interpretations in Spanish, From Padilla-Reyes (2015)

A novel contribution of this study was to show not only a delay in distributive interpretations, as had been shown in earlier work in other languages, but to also show that collective interpretations were slow. He further showed that the three quantifiers were correlated in their emergence, consistent with the hypothesis of Dotlačil (2010) that quantifiers form a collective-distributive lexical scale. Also, in support of the latter's hypothesis, he shows that general lexical development, as measure by the Test de Vocabulario en Imágenes Peabody (TVIP – Dunn & Lugo 1984) is predictive of children's interpretations.

It is important to point out that in Pagliarini et al. (2012), adults were said to accept the definite *i/le* subjects as collective 50% of the time. This seemed improbably, at least from the perspective of Spanish, in which it appeared to give a more categorical 100% collective interpretation, at least intuitively. Grinstead, Padilla-Reyes & Nieves-Rivera (2021) indeed confirmed that adult Spanish speakers take not only the definite *los*, but also the indefinite *unos* in subject position to be collective 100% of the time.

Finally, the authors propose what they refer to as the Pragmatic Scale hypothesis. They stated that these collective and distributive quantifier interpretations can be linked by a pragmatic scale in the lexicon. This is independent of a lexical measure. The connection between *some* is derived in its implicature and is stronger than *each* which is derived via entailment.

Following up the finding that general lexical development is predictive of children's interpretations of quantifiers, Oates decided to include not only lexicon, but also working memory, set shifting and inhibition tests to see if any of these factors are correlated with children's collective-distributive interpretations. The idea was that the plural collective quantifiers were in fact ambiguous between being collective vs. distributive, in contrast to distributive *each/cada*. From this perspective, following natural language processing research, it could be expected that executive function abilities might help disambiguate collective vs. distributive interpretations.

<u>Oates (2017)</u>

In this experiment, lexicon, working memory, set shifting, and inhibition are used to explain children's collective- distributive interpretations. 29 English-speaking children between the ages of 7 and 8 were given the Peabody Picture Vocabulary Test (PPVT). This test measures children's standardized vocabulary. In addition, they were given the EXAMINER battery of executive functioning and cognitive ability. Lastly, they were given a True Value Judgement Task to measure their semantic interpretations of *each, some* and *the*. This is a task watching compilations of short stop-motion videos depicting collective or distributive actions performed by the minion characters (from the movie *Despicable Me*), as in the previous experiment, but this time with English language audios, with a manipulation in the quantifier (either collective or distributive). Then, the children are asked to assess whether the statement made was correct or not for the video being shown.

After the experiment was given, it was shown that the children were far less categorical in interpretations of the three quantifies (*some, the, each*) than the adults. This is also linked with the development of those children. Lexical development (PPVT) is a strong, significant predictor of the ability to reject each in collective contexts, and some in distributive contexts- which is the adult like behavior. Furthermore, the inhibitory component of executive function abilities was also predictive of distributive and, especially, collective interpretations. The Spanish language component of the project worked with a similar number and age of monolingual Spanish-speaking children in Puerto Rico, who took the original TVJT and the same executive function measures as the English-speaking children. They were also given the TVIP lexical measure, as in the previous experiment.

In contrast to the previous study, then, Oates tested 7-year-olds who were monolingual English speakers and 7-year-olds who were monolingual Spanish-speakers. She found that collective interpretations in her adult controls were 100% categorical in rejecting *some* and *the* in subject position in distributive contexts, confirming what had been shown for child Spanish. The inhibition measure, the Flanker Task, was significantly predictive of *some/unos* and *the/los* interpretations, but not of *each/cada* interpretation, as one would expect if inhibition were playing a disambiguation role. That is, *each/cada* is not ambiguous because its meaning is derived via entailment, while *some/unos* and *the/los* derive their meaning via conversational implicature, if Pagliarini et al (2012) and Padilla-Reyes (2018) are correct.

<u>Summary</u>

Across all languages, children take a significantly longer time in developing understandings for the quantifiers “each, some, and the”, and their relations in collective and distributive contexts. Children are less restrictive with the use of “each” in incorrect collective contexts. This is thought to be related to the “yes-bias”. Later, it was discovered that the collective and distributive quantifiers appear to develop in a correlated fashion, supporting the idea of a Collective-Distributive Pragmatic Scale. In Grinstead 2021, general lexical development was found to be a significant predictor of children’s interpretations of quantifiers. Working with that idea, Oates added a battery of executive functioning tasks, and linked inhibition as a predictor of distributive and collective interpretations. Later, it was found that inhibition plays a significant role in “some” and “the” interpretations, but not “each”. Showing that inhibition does not disambiguate “each” as its meaning is expressed as an unambiguous entailment.

The Development of Numerical Cognition

Numerical cognition is a factor that may have an influence on a child’s ability to understand collective and distributive interpretations of quantifiers. When thinking about the implications of the quantifier *each*, there is an inherent numerical meaning to the word, and this numerical cognition might have an influence on such interpretations. Thus, we measure numerical cognition to determine whether its covaries with children's collective and distributive interpretations.

Siegler & Opfer (2003)

In Siegler & Opfer, children's and adults' numerical estimation systems and their mental representations were tested. This experiment was run in four groups of 32 children. The groups were second graders, fourth graders, sixth graders and adults. The participants were given the "number line task", a task in which a 25cm line has the ends labeled 0 and 100, and participants are asked to estimate the place of a given number on the line. The results are as shown in the graph below.

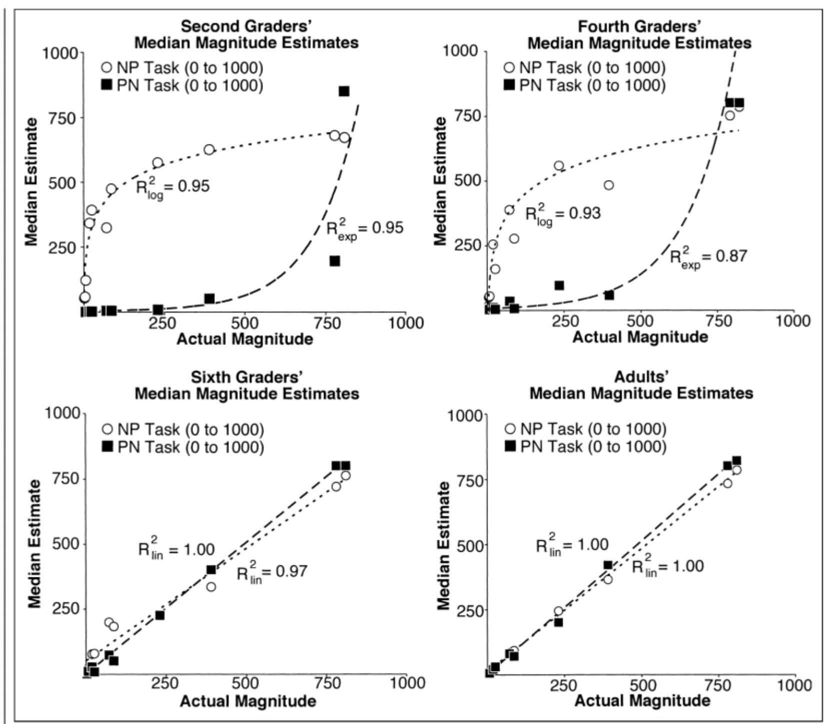

Fig. 2. Median estimates on the number-to-position (NP) and position-to-number (PN) tasks for the 0–1,000 number line. Results are displayed separately for each age group. The dotted and dashed lines indicate the best-fitting functions, and for each function the percentage of variance accounted for (R^2) is indicated.

Figure 4- Median magnitude estimates as related to age and likeability

The results showed that with age, children's estimates of placing a number to a position change substantially. Second graders' median estimates are better fit on a logarithmic model rather than a linear one. In fourth graders, their estimates were fit equally well by both models. In sixth graders' and adults' estimation, their estimates hit closer to a linear function. These findings indicate that over time and numerical experience, children work from logarithmic to linear representation of estimates on a number line. This experiment shows that one can understand the "adult-like" processes that go on in a child's brain by understanding if their number line estimates are linear or logarithmic. There are also other ways in which a child's numerical understanding can be tested.

Halberda, Mazzocco & Feigenson (2008)

In this 2008 experiment, the foundational Approximate Number System (ANS) is tested in 14-year-old children by using inexact number representations. A numerical discrimination task was created where 2 arrays of dots were shown side by side. On each side, there was a different colored dot, all dots varying in size and number. The children are then asked to click the "blue" or "yellow" button within 200 ms of seeing the stimulus on a computer keyboard to indicate the side with the most dots (see figure 7). When controlling for cognitive and performance factors, there is a statistically significant difference between performance on this ANS task and past standardized math test results.

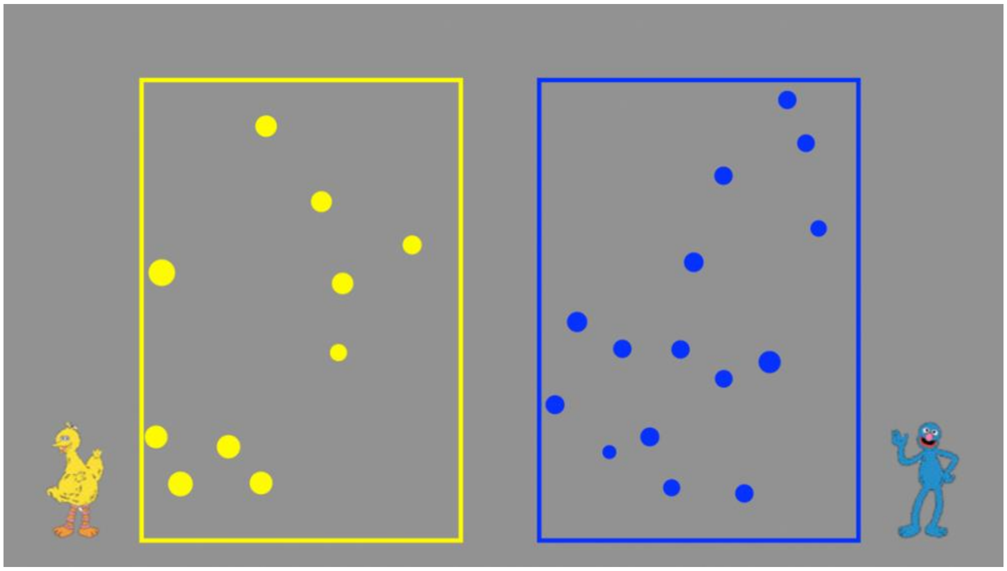

Figure 5: a screen capture of the Panamath test

In conclusion, this “Panamath test” tests the Approximate Number System in children through very implicit, innate, non-symbolic ways. This type of test seems relatively non-linguistic in the sense that quantity words do not play a significant role in participants’ judgments.

Geary 2018

In this study, preschool quantitative competencies that predicted children’s school entry Number System Knowledge (NSK) were studied. Specifically, distributivity in numeral recognition, and knowledge of the count list were used to measure number understanding. The preschool kids were given the give-a-number task up to 6. However, when testing first graders, the number sets task was used. This task is when integers from 2 through 9 are put on flashcards, and the children were asked to solve the addition of two flash cards and given a time limit of 60 seconds to complete as many as possible. A d-prime score was calculated through determining the hits, misses, correct rejections and false alarms. Through this, one can understand the participants' comprehension of numbers in a set, and their distribution within the groups of flashcards. This aspect of numerical comprehension could plausibly be relevant to collective-distributive interpretations, which is why we chose to use Geary's Number Sets Task as a potential cognitive precursor to our quantifier comprehension measure. This task has an innate distribution aspect, as the dots are distributed between the similar dominos.

<u>Summary</u>

In understanding the numerical processes that occur in a child's mind, many experiments are given to determine the innate numerical knowledge. Adult-like representations are determined by using number line task. Children start with logarithmic estimates and move toward linear estimates as they grow in their numerical ability. To test the Approximate Number System of a child, Panamath uses an implicit, non-symbolic testing strategy. Lastly, Geary tested Cardinality Principle Knower (CPK) status and numeral recognition with the Number Sets Task. Testing the CPK status is another way to visually test distributive skills in children. Distributive in the number domain may correlate with distribution in the linguistic realm. This is also an innate task for quantitative competency.

Dialect Variation

Up to now, we have seen that across languages, there is a consistent finding that distributive quantifiers are late to emerge in children's comprehension. We have also seen that children's numerical cognition can be measured independently of their language. It has been proposed (Grinstead, Padilla-Reyes & Nieves-Rivera 2021) that Approximate Number System knowledge feeds the lexical component of language. This is theoretically linked to the quantitative meanings of the distributive quantifier *each* and the collective quantifier *some*, in that both of these quantifiers have a quantity meaning that is interpreted in specific ways. Given that lexicon is one of the features of language that varies by dialect and given that previous work has shown that lexical development predicts distributive and collective interpretations, we explore whether speaking different dialects of English is associated with different levels of distributive and collective interpretations.

Washington and Craig (1998)

This article looks at the dialectal use by African American children who differ in Socioeconomic status and gender. They examined 66 five- and six-year-old boys and girls in the Detroit area. The experimenters collected free-play language samples using individual microphones to record for 15-20 minuets. These recordings were taken during adult-child interactions with an adult that spoke African American English (AAE) during a "play time". The samples were then transcribed using the CHAT conventions of Children's Data Exchange System then scored using the scoring criteria of Loban (1963) and analyzed using C-units. After a two-way analysis of variance, the results showed that the socioeconomic status of a child's family reflects significantly more dialect use than children from middle socioeconomic households. Additionally, there is significantly more dialect use from the boys than the girls. This study shows the impact of socioeconomic status on the dialect of a child, and these results lead investigators to believe that low socioeconomic status children have few opportunities to be exposed to others outside of their linguistic community, while middle class children have more exposure to mainstream culture, and linguistic forms outside of their own.

Charity (2004)

In this 2004 experiment, familiarity with school English in African American children and its relation to early reading achievement was measured. 217 urban African American students aged 5-8 were assessed for sentence imitation and reading skills. The majority of students were from low socioeconomic status (SES) backgrounds, based on their eligibility for free or reduced-price school lunch program. The reading achievement test assessed how well the children could read and pronounce out loud words of increasing difficulty and fill in blanks that are syntactically and semantically appropriate in stories. Another method used is a sentence imitation task, where the experimenter says a sentence out loud, and the child has to repeat exactly what the experimenter says. The phonological dialectal differences in the pronunciation of the words are then measured by the experimenter. Due to the combined results of the reading achievement test and the sentence imitation task, the data suggests that SES differences and racial dialectal differences lead to different language norms and expectations, including the child's familiarity with school English. The group differences with the reading achievement test are associates with racial and SES difference. However, there is individual variation within this, and familiarity with school English may be one of these. School English, which we will operationalize as Mainstream American English, following Seymour, Roeper & De Villiers (2005); was predictive of reading achievement.

In summary, African American Vernacular English (AAVE) and Socio-economic Status account for dialect differences among African American children and are predictive of reading outcomes. On this basis, it seems important to measure both of these variables in our study of developing quantifier interpretations in children who may speak AAVE.

Summary & Research Questions

Across the world, children seem to acquire distributive quantifier interpretations at the surprisingly old age of 9 or 10 years old. With regard to the quantifier “each”, children ages 4-6 are prone to accepting both distributive and collective interpretations in both congruent and incongruent contexts, e.g., contexts that match distributive sentences with distributive pragmatic contexts and those that do not. The children approach adult-like comprehension of quantifiers from 9 to 10 years of age. As more work began on this topic, it became known that general lexical development is predictive of children’s interpretations of quantifiers. Adding to this idea, the working memory and inhibition of a participant was also discovered to play a significant role in the rejection of incorrect collective-distributive interpretations. Because quantifiers have an inherent numerical meaning to them, we explore whether numerical cognition may play a role in the development of quantifier interpretations. In a number line placement task, children’s understanding become more adult like from 4th to 7th grade. It is also important to test the Approximate Number System in children using very implicit, innate, non-symbolic means, as this may be the type of numerical cognition that underlies quantifier use. Dialectal variation is also taken into account because even though general lexical development is predictive of children’s interpretations of quantifiers, dialectal variation may not be connected with innate number knowledge. Thus, there is no data on dialect variation in relation to development of collective-distributive interpretations or numerical development. This leads to the three research questions.

RQ1 - Do non-linguistic measures of number predict collective-distributive interpretations?

RQ2 - Does dialect variation matter for the development of collective-distributive interpretations?

RQ3 - Does dialect variation matter for numerical development?

Methodology

Participants

In this study, 54 child participants from Columbus, Ohio began, however only 31 participants were included. A total of 23 children were excluded for not passing the filler items in our dependent variable task (Truth Value Judgement Task), or for not being monolingual English speakers. To participate, the children's guardians had to complete and sign an OSU IRB-approved consent form. The children had to be monolingual English speakers, have no previous record of speech or hearing problems, and they had to be within the age range of six and seven years old. Our sample mean age = 82.1 months, with a standard deviation in age of 6.9 months and an age range of 71-94 months.

Procedures

Preliminarily, a questionnaire and consent form are given to the parent of a child that is between 6 and 7 years of age. The questionnaire determines the child's name and date of birth, along with determining if there are any speech or hearing issues and developing healthily. It also determines if the child is multilingual or monolingual, and the maternal and paternal levels of education. For our purposes, children were determined to be "multi-lingual" if they had other family members living in their households, speaking in a language other than English. Any child with speech or hearing problems, or multilingual kids, were excluded from the study.

Truth Value Judgment Task

A Truth Value Judgement Task (TVJT), following Crain & McKee (1985), was given. The TVJT uses the same videos as in Grinstead, Padilla-Reyes & Nieves-Rivera (2021), but with English language audio recordings. In the scenarios, participants see minions (from the movie *Despicable Me*) first, practicing with warm up questions using "all" or "none" quantifiers in sentences stating that "all the minions" had moved a horse or "none of the minions" had moved a horse. Feedback was given on these items, but none was given thereafter.

Then moving to acting out collective tasks (pushing a rock together), distributive tasks (pushing a rock individually), and filler tasks (collecting *all* or *none* of the roosters). There is a voice-over accompanying the video clips, with sentences such as "some minions pushed a rock", which is taken to be collective, and "each minion pushed a rock", which is taken to be distributive, based on our previous research with adults. The participants then have to identify if the voiceover accompanying the video clip as correct or not. At the beginning of the task, there was simple questions presented such as "The minions are working on the farm, and they have to open a door. It looks hard to open. How many of them will it take to open it?". This audio would be accompanied by a video of many minions attempting to open a door yet being unable to open it. The correct response in this scenario would be to accept the statement "I know how many it took. No minion could open the door".

For the experimental section of the task, there were eight sentences with *each*, half presented in consistent, distributive contexts and half presented in inconsistent, collective contexts. Similarly, there were eight sentences with *some*, half collective/consistent and half distributive/inconsistent. One example of *some* in a collective context is “The minions are working on the farm, and they have to move rocks. There’s only one and it looks pretty heavy. How are they gonna do it?”. This is accompanied by a video of many minions working together to push one rock. Then, the correct response would be to accept the statement “I know how they did it. Some minions moved a rock”. Scattered throughout the presentation of these experimental tasks, there were filler sentences inserted. One such filler is “The minions are working on the farm, and they have to climb a rock in order to pick fruit. That rock looks hard to climb. How many of them will be able to climb it?”. This audio would be presented in tandem with a video of one minion climbing a rock, and the child would then have to accept the answer “I know how many could. One minion could climb a rock”. These filler items were inserted to ensure that the participant was actively participating and paying attention to the task at hand. There were 12 filler items. Children were only included in the sample if they answered 10, 11 or 12 filler items correctly, which is significantly above chance.

Panamath

A Numerical Discrimination task called “Panamath” (Halberda, Mazzocco & Feigenson 2008) was also administered. In this test, colored blue and yellow dots appear on the screen for .2 seconds, and then disappear from the screen. The participant then has to decide which side (blue or yellow) had the most dots, which they indicate by typing the arrow key on the computer keyboard corresponding to the side of the screen with the most dots. This test is used to measure children’s approximate number system representations, which are distinct from exact quantities.

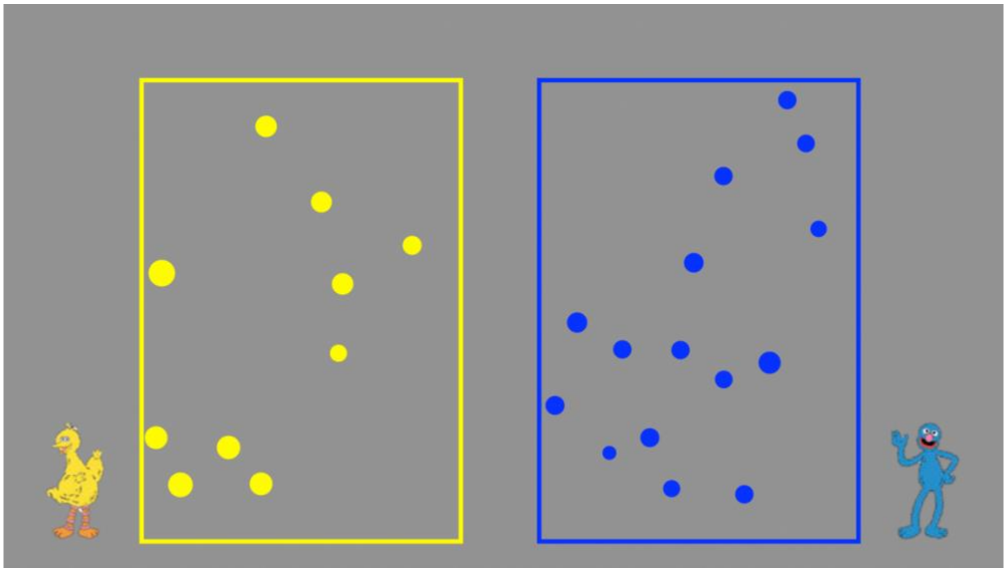

Figure 6: a screen capture of the Panamath test

Scores for Panamath were recorded as percent correct.

<u>Number Line</u>

A Number line estimation task (Siegler & Opfer 2003) was given to measure the degree to which children’s estimation is a linear function of the quantity they are estimating. There are two versions of this task: the “Symbolic Number Line Task” with Arabic numerals at each end of the number line, and the “Non-symbolic Number Line Task” with dots at each end of the number line. A box with a random number of dots appears on the screen for a short duration of time, and the participant has to identify where that number belongs on the number line. This evaluates the numerical-spatial comprehension of a participant.

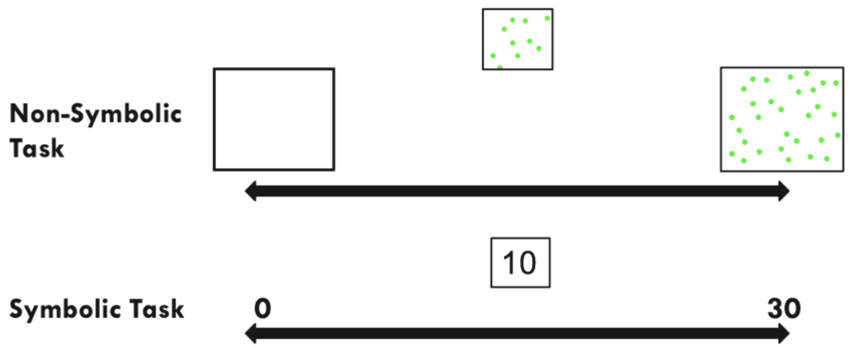

Figure 7: a screen capture of the Number line estimation task.

Scores for the number line tasks are converted into a "proportion logarithmic" score, referred to as Lambda, by Kim & Opfer (2014).

Number Sets

The Number Sets task (Geary et al. 2018) measures a child's Number System Knowledge, through the use of addition. The children have a specific amount of time to work through a worksheet with "dominos" on it. If the "dominos" add up to a certain number (5), they have to circle it. The paper is then scored according to "hit", "miss", "false acceptance", and "correct rejection". These scores are then counted and used to determine a d- prime score for each child.

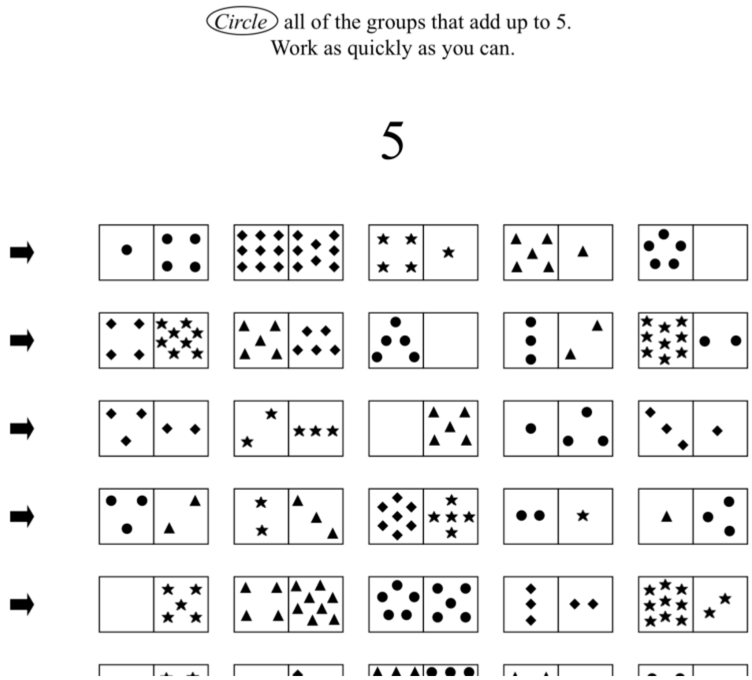

Figure 8: A screen capture from the number sets task.

Diagnostic Evaluation of Language Variation (DELV)

The DELV task stands for “Diagnostic Evaluation of Language Variation” (Seymour, Roeper & De Villiers 2005) and it is a measure of language variation. This task was verbally administered by a researcher to the participants, and their phonological and morphological responses were recorded and scored according to the DELV scoring sheet. The results are either “mainstream English”, “some dialect variation” and “strong dialect variation”.

Results

Descriptive Statistics

In the following table, we give the mean scores on each measure, together with the standard deviation for each group of children, categorized by the DELV. For the TVJT answers, we give the mean acceptance of two incongruent sentence-scenario pairings (*each* in collective contexts; *some* in distributive contexts).

	Number Sets	Symbolic Lambda	Non-symbolic Lambda	Panamath	Maternal Level of Education	Age Months	*each* Collective (Incongruent)	*some* Distributive (Incongruent)
Mainstream American English (n = 22)	0.28 (1.46)	0.24 (0.33)	0.43 (0.40)	86.36 (10.13)	16.71 (2.13)	83.82 (6.37)	1.95 (2.06)	3.18 (2.17)
Some Variation from MAE (n = 7)	0 (1.07)	0.27 (0.48)	0.33 (0.45)	86.77 (6.31)	16 (0.00)	80.14 (6.49)	4.14 (1.21)	5.14 (0.69)
Strong Variation from MAE (n = 2)	-0.23 (1.62)	0.29 (0.40)	0.58 (0.6)	73.05 (0.78)	NA	80.50 (10.61)	4.5 (0.70)	6 (0.00)

Table 6 – Descriptive Statistics for Study Measures

Inferential Statistics

Correlations

To determine whether there is a statistically contingent relationship between our numerical measures and our linguistic measures, a Pearson Product Moment Correlation was calculated among them. We see in the following table that none of the numerical measures correlated with our measures of distributive and collective interpretations.

	Each Collective	*Some* Distributive	Number sets	Symbolic lambda	Non-symbolic lambda	Panamath
Each Collective	1	0.52**	-0.296	-0.008	-0.006	0.015
Some distributive	0.52**	1	-0.326	0.131	-0.179	-0.192
Number sets	-0.296	-0.326	1	-0.372	-0.504*	0.590**
Symbolic lambda	-0.008	0.131	-0.372	1	0.009	-0.439
Non-symbolic lambda	-0.006	-0.179	-0.504*	0.009	1	-0.156
Panamath	-0.015	-0.192	0.590**	-0.439	-0.156	1

Table 7– Pearson Correlation Coefficients (* - $p < .05$; ** - $p < .001$)

However, we see that collective and distributive interpretations do correlate in our sample and that several of the number measures correlate among themselves, also.

Group Comparisons

Next, we compared our dialect groups on our number and language measures. In our sample of 35 children, 31 answered the DELV. Only 2 of the children who answered the DELV were classified as “strong variation”, while 7 were classified as “some variation” and 22 children were classified as “Mainstream American English”. For purposes of statistical comparison, we collapse the “some variation” and “strong variation” groups into one “variation” category. By independent samples t-test, there were no significant differences for any of the four number measures between the Mainstream American English group and the Variation Group ($p > .05$). In contrast, there were significant differences between the “variation” and “Mainstream American English” groups for acceptance of *each* in collective contexts ($t(29) = 3.110$, $p = .004$, Cohen’s D = 1.230), as illustrated in Figure 8.

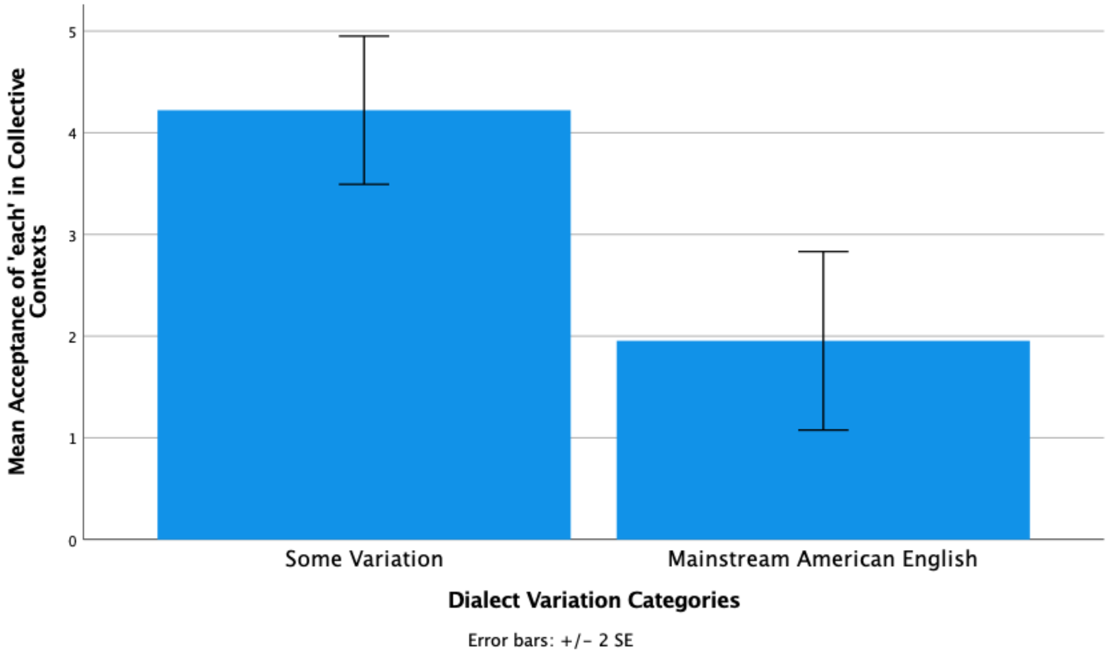

Figure 8- Dialectal variation correlated with acceptance of ‘each’ in collective contexts

Similarly, we see a significant difference in the acceptance of *some* in distributive contexts, between the two dialect groups, with the Mainstream American English speakers accepting significantly less ($t(29) = 2.881$, $p = .007$, Cohen’s D = 1.140), as illustrated in Figure 9.

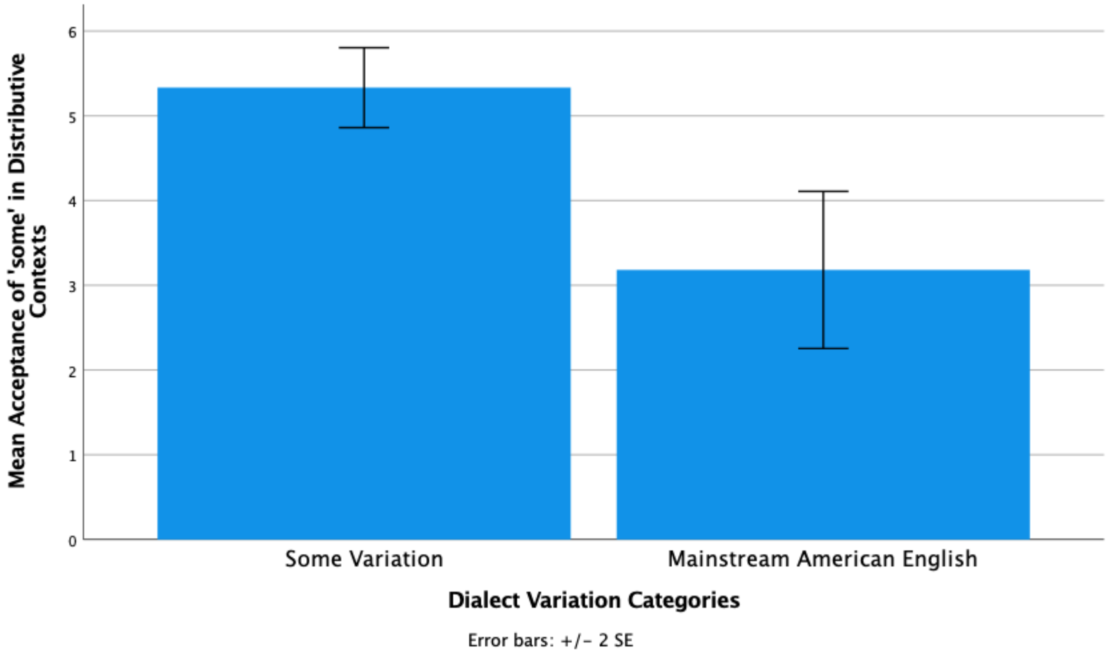

Figure 9 - Dialectal variation correlated with acceptance of ‘some’ in distributive contexts

Discussion

RQ1 - Do non-linguistic measures of number predict collective-distributive interpretations?

While there is no statistically significant correlation between non-linguistic measures of number and collective-distributive interpretations, is seems as if the data is heading that way. The Number Sets task and *some* interpretations are correlated at a value of -0.324 (p = .09). Likewise, Number Sets performance is significantly related to Non-Symbolic Lambda and Panamath scores. This shows that the number measurements are significantly related to one another in our sample that there were no obvious problems is measuring the numerical constructs we were interested in.

RQ2 - Does dialect variation matter for the development of collective-distributive interpretations?

There were significant differences in children's interpretations of collective and distributive sentences, as a function of their dialect variety. Children who were speakers of MAE had more adult-like scores in that there was a lower acceptance of *some* in distributive contexts and *each* in collective contexts than there was in the children in the Variation sample. As in previous work in Spanish (Grinstead et al. 2021) and English (Oates 2017), collective and distributive interpretations correlated across the sample. While we did not have extensive enough language measures to know which aspects of dialect mattered for this distinction, it seems possible that children who are learning multiple dialects of English (e.g., African American Vernacular English as well as Mainstream American English) could have smaller lexicons in each dialect. Such a finding would be consistent with current work showing less adult-like collective and distributive interpretations in Spanish-English bilingual children, vs. monolingual Spanish-speaking children (Lingwall-Odio & Grinstead 2020). In this bilingual-monolingual comparison, the bilingual children had higher inhibition scores, but lower lexical scores and had less adult-like collective-distributive interpretations. Future work on the role of dialect on collective-distributive interpretation should also measure lexicon.[1]

RQ3 - Does dialect variation matter for numerical development?

While dialect variation and numerical development did not statistically correlate, the Number Sets measure of numerical knowledge and interpretations of *some* in distributive contexts (the

[1] Fogel (2020) shows that in this same sample of children, there were no significant differences between children in the MAE and Variation groups on 3 different measures of inhibition (Flanker, Continuous Performance and Anti-Saccades).

implicature interpretation) were very close to being significant, which, given our small sample, may or may not prove to be meaningful in a larger sample. Of perhaps greater significance is the fact that there were no significant differences between our MAE and Variation groups for any number measure, which is consistent with the hypothesis that mathematical development is unimpeded by the potential challenges posed by multilingualism that manifested in our quantifier interpretation task.

Limitations

There are a few limitations of this study, the biggest one being the sample size. A sample size of 31 participants is not ideal for correlational analyses, as in our test of the associations between language and number. For our means comparisons, however, we found significant differences with Cohen's D values above 1.0. Cohen considers effect size of .8 or larger to be "large" effect sizes (Cohen 1988). Thus, our finding that dialect differences exist for collective and distributive interpretations seems robust. In future work, we hope to collect enough data to carry out more meaningful correlational analyses.

In addition to that, many of our "language variation" participants failed to pass the TVJT. They did not make it past the first round of warm up questions, even though the researchers paused and explained the instructions many different times. Due to their failure on this task, they did not receive the other numerical cognition tests. This is an important issue to look into- why did they perform poorly on the TVJT, and how would their scores have affected the numerical cognition scores.

As mentioned, previous work in monolingual English-speaker, monolingual Spanish-speakers and in bilingual Spanish-English speakers has shown that children's lexical scores were predictive of their collective-distributive interpretations. Here we did not measure lexical development, because our shared protocol measured number and inhibition extensively (3 measures each) in addition to our dialect measure and our TVJT. We saw in Fogel (2020) that the bilingual advantage-type phenomenon of greater inhibition scores in bilingual children did not occur in bi-dialectal children. The differences between monolinguals and bilinguals in bilingual advantage studies, however, are always with small-ish effect sizes, and sometimes do not occur at all. The differences in lexical development in such studies, however, is usually quite large, and could possibly also characterize our populations here. Hopefully future work can explore some of these questions.

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Appendix

<u>Truth Value Judgement Task Scentences</u>

EXPERIMENT

I. Catch geese

i. Distributive: The minions are working on the farm, and they have to catch a goose. There is more than one. How are they gonna do it?
ii. Collective: The minions are working on the farm, and they have to catch some geese. There is only one. How are they gonna do it?
iii. Target sentences:
    a. I know how they did it. The minions caught a goose.
    b. I know how they did it. Some minions caught a goose.
    c. I know how they did it. Each minion caught a goose.

II. Carry bags

i. Distributive: The minions are working on the farm, and they have to carry a bag of food. There is more than one and they don't look heavy. How are they gonna do it?
ii. Collective: The minions are working on the farm, and they have to carry bags of food. There is only one and it looks pretty heavy. How are they gonna do it?
iii. Target sentences:
    a. I know how they did it. The minions carried a bag.
    b. I know how they did it. Some minions carried a bag.
    c. I know how they did it. Each minion carried a bag.

III. Find geese

i. Distributive: The monsters are working on the farm, and they have to take care of some geese. The monsters can't find **them**. How are they gonna do it?
ii. Collective: The monsters are working on the farm, and they have to take care of a goose. The monsters can't find **it**. How are they gonna do it?
iii. Target sentences:
    a. I know how they did it. The monsters found a goose.
    b. I know how they did it. Some monsters found a goose.
    c. I know how they did it. Each monster found a goose.

IV. Trap roosters

i. Distributive: The minions are working on the farm, and they have to trap a rooster. There's more than one. How are they gonna do it?
ii. Collective: The minions are working on the farm, and they have to trap some roosters. There's only one. How are they gonna do it?
iii. Target sentences:
    a. I know how they did it. The minions trapped a rooster.
    b. I know how they did it. Some minions trapped a rooster.
    c. I know how they did it. Each minion trapped a rooster.

V. Move rock

i. Distributive: The minions are working on the farm, and they have to move a rock. There's more than one and they don't look heavy. How are they gonna do it?
ii. Collective: The minions are working on the farm, and they have to move rocks. There's only one and it looks pretty heavy. How are they gonna do it?
iii. Target sentences:
    a. I know how they did it. The minions moved a rock.
    b. I know how they did it. Some minions moved a rock.
    c. I know how they did it. Each minion moved a rock.

VI. Plant trees

i. Distributive: The minions are working on the farm, and they have to plant a tree. There's more than one. How are they gonna do it?
ii. Collective: The minions are working on the farm, and they have to plant some trees. There's only one. How are they gonna do it?
iii. Target sentences:
    a. I know how they did it. The minions planted a tree.
    b. I know how they did it. Some minions planted a tree.
    c. I know how they did it. Each minion planted a tree.

FILLERS

I. Open door

i. None/one: The minions are working on the farm, and they have to open a door. It looks hard to open. How many of them will it take to open it?
ii. Target sentences:
    a. I know how many it took. No minion could open the door.
    b. I know how many it took. One minion could open the door.

II. Find pig

i. None/one: The minions are working on the farm, and they have to find a pig. It looks hard to find. How many of them will it take to find it?
ii. Target sentences:
    a. I know how many it took. No minion could find a pig.
    b. I know how many it took. One minion could find a pig.

III. Climb rock

i. None/one: The minions are working on the farm, and they have to climb a rock in order to pick fruit. That rock looks hard to climb. How many of them will be able to climb it?
ii. Target sentences:
    a. I know how many could. No minion could climb a rock.
    b. I know how many could. One minion could climb a rock

Language Development Questionare

Basic Information

First Name and Surnames of the child:________________________ Date of Birth: _____

First Name and Surnames of the parent/guardian (mother or father)_________________

Total Number of Years in School:______________

First Name and Surnames of the parent/guardian (mother or father)_________________

Total Number of Years in School:______________

Development

1. Did anything unusual occur with the pregnancy or birth?

If so, what was it?____

Child's birth weight: ______________________________________

Were there problems after birth?____________________________

2. At what age did your child first reach these milestones?

Sat alone___________________ Stood alone_________________

First words_________________ Combined words_____________

Potty trained________________ Walked alone_______________

3. Do you have any concerns about your child's development? Yes No

If so, what?____

____

4. Hearing

Does your child have hearing problems? Yes No I don't know.

Has your child had ear infections? Yes No I don't know.

5. Language

Does your child hear any language other than Spanish on a regular basis? Yes No

If so, what language is it and how frequently?____________________________

Do you have any concerns about the development of your child's speech or language? Yes No

If so, what are they? ____

Does your child have a history of problems with speech or language? Yes No

Has your child's speech or language ever been formally assessed? Yes No

If so, when and what for?____

Is there a history of speech or language delays or problems in your family? Yes No

If so, what kind?____

What is the relationship of the person(s) with the problem(s) to your child?_______

DELV Questions

Part I Language Variation Status

Repetition Rule: Repeat the item once if the child does not respond or if the child requests it. If the child does not respond after repetition of the item circle NR for "No Response" and proceed to the next item.

Materials: Stimulus Book; see Examiner's Manual for complete administration and scoring directions.

Introduction: When you introduce the test to the child, say: **Most people think that talking is fun. Today I'm going to give you a test about talking that has been made for children just like you. Lots of the pictures I'm going to show you and stories I'm going to tell you are about children or people just like you. Some of the test is for older children and may be hard for you. Some of the test is for younger children and may be easy for you. Sometimes I'll say things that are funny or hard to understand, but most of the time you'll be able to figure out the answer because it's easy. When we finish this test tell me how you liked it. Let's begin!**

Recording/Scoring: Circle the word that matches the child's production of the target word/target phoneme (indicated in **green** type). Use the "Other" column to record any production not listed in columns A or B. Calculate the subtotals by adding the number of responses in columns A and B only.

Partial Response Rule: See Examiner's Manual

Trial Item A: Turn to the page in the Stimulus Book marked Part I Language Variation Status. Say: **I'm going to show you some pictures and tell you what I see. Then I want you to say exactly what I said. Let's try one.** Turn to the page marked Part I—Trial Item A and Items 1–5. Point to the picture in the upper left-hand corner of the page and say: **I see a man.** If the child imitates your sentence exactly, say: **Good. Let's do some more.** If a child does not imitate the sentence exactly, say: **Let's try that again. Say what I say. I see a man. You say it.** Prior to the test session review the Examiner's Manual for instruction on what to do if a child does not imitate your sentence. Proceed to Item 1.

Item Point to each picture and say:	A	B	C	D
1. **I see her brushing her teeth.**	teef	teeth	Other: ______	NR
2. **I see a bird taking a bath.**	baf	bath	Other: ______	NR
3. **I see a smooth table.**	smoov/smoo	smooth	Other: ______	NR
4. **I see that fish breathe under water.**	breave/breade	breathe	Other: ______	NR
5. **I see a gift near the baby.**	gif	gift	Other: ______	NR
Subtotals for Items 1–5				

Recording/Scoring: The verb or verb form being assessed is listed in the green bar above each set of items, as are the criteria for deciding if a response belongs in column A, B, or C. Circle the answer that corresponds with the verb form the child uses. If the child responds with another verb, look at the criteria in the green bar or see Appendix A to determine where the response belongs. Calculate the subtotals by adding the number of responses in columns A and B only.

Trial Item B: Say: **Now I'm going to show you some more pictures and tell you something about each one. I want you to look at the pictures and finish what I say about them. Let's try one.** Turn to Trial Item B in the Stimulus Book. Direct the child's attention by pointing to the pictures as instructed in parentheses. Say the **boldfaced** words and emphasize the *italicized* words. (Point to the hay.) **I see hay.** (Point to the carrots.) **I see carrots.** (Point to the horses.) **The *horses* eat hay,** (Point to the rabbit.) **but the *rabbit* . . .** (eat/eats carrots). If the child completes Trial Item B appropriately by providing a verb, turn to the page marked Item 6 and continue testing. Prior to the test session review the Examiner's Manual for instruction on what to do if a child does not provide a verb or if a child uses a plural subject.

Item	A	B	C	D
3rd Person Singular Have/Has. Response includes the verb:	**have or got**	**has**	**something else**	**NR**
6. (Point to the little kites.) **I see little kites.** (Point to the big kite.) **I see a big kite.** (Point to the boys.) **The *boys* have little kites,** (Point to the girl.) **but the *girl* . . .**	have got	has	big kite(s) ______	NR
7. (Point to the dogs' tails.) **I see short tails.** (Point to the cat's tail.) **I see a long tail.** (Point to the dogs.) **The *dogs* have short tails,** (Point to the cat.) **but the *cat* . . .**	have got	has	long tail(s) ______	NR

3rd Person Singular -s, -es. Response includes a verb:	without -s, -es	with -s, -es	something else	NR
8. (Point to the sleeping bags.) **I see sleeping bags.** (Point to the bed.) **I see a bed.** (Point to the boys.) **The *boys* always sleep in sleeping bags,** (Point to the girl.) **but the *girl* always . . .**	sleep	sleeps	in bed	NR
9. (Point to the horses.) **I see horses.** (Point to the bike.) **I see a bike.** (Point to the girls.) **The *girls* always ride horses,** (Point to the boy.) **but the *boy* always . . .**	ride	rides	a bike riding a bike	NR
10. (Point to the plates.) **I see plates.** (Point to the glasses.) **I see glasses.** (Point to the boys.) **The *boys* always wash the plates,** (Point to the girl.) **but the *girl* always . . .**	wash clean	washes cleans	cups/glasses washed the glasses	NR
11. (Point to the wagon.) **I see a wagon.** (Point to the stroller.) **I see a stroller.** (Point to the girls.) **The *girls* always push the wagon,** (Point to the mom.) **but the *mom* always . . .**	push	pushes	stroller	NR

3rd Person Singular Do/Does. Response includes the verb:	do	does	something else	NR
12. (Point to the girl.) **This *girl* likes to swim,** (Point to the boy and shake your head to indicate "no.") **but this *boy* . . .**	don't do not	doesn't does not	likes to stand	NR
13. (Point to the boy.) **This *boy* likes to play basketball,** (Point to the girl and shake your head to indicate "no.") **but this *girl* . . .**	don't do not	doesn't does not	likes to watch	NR
Subtotals for Items 6–13				

Trial Item C: Say: **Now I want you to answer my questions. Let's try one.** Turn to Trial Item C. (Point to the picture of the dog standing on its hind legs.) Say: **Look at the dog. Why is the dog standing on his back legs?** (To get food.) If the child completes Trial Item C appropriately by answering the question, say: **Now let's do some more.** Turn to Item 14 in the Stimulus Book and continue testing. Prior to the test session review the Examiner's Manual for instruction on what to do if a child does not appropriately answer the trial question or does not use a plural subject.

Copula (or Auxiliary) Was, Were. Response includes a plural subject plus:	was	were	something else	NR
14. (Point to the dirty clothes in the basket on the left.) **See the lady with the clothes. She said the clothes needed to be washed. So she washed them.** (Point to the washed clothes on the clothes line.) **Why did she wash these clothes?**	They was	They were	They dirty It was dirty	NR
15. (Point to the picture on the left.) **These girls couldn't get out of bed, and their mother gave them some medicine.** (Point to the picture on the right.) **Today, they are not sick.** (Point to the picture on the left again.) **Why did their mother give them medicine *yesterday*?**	They was	They were	They sick She was sick	NR
Subtotals for Items 14–15				
	A	B		
Part I Totals for Items 1–15				

Note: See the Examiner's Manual for more examples of column A, B, and C responses.